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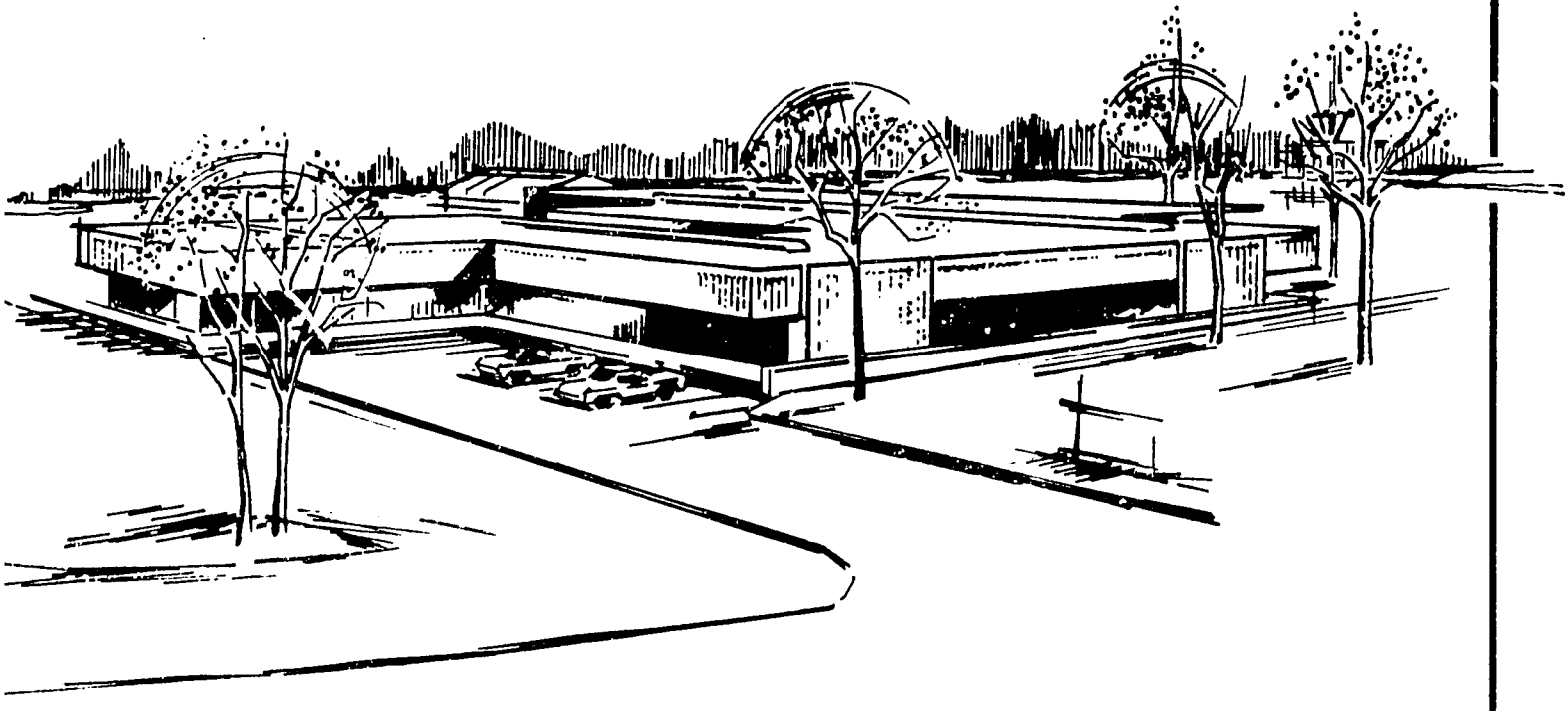

PROGRESS REPORT
1977

The International Fertilizer Development Center (IFDC) is a public international organization dedicated to the goal of increasing agricultural productivity in developing countries through the use of improved fertilizers and fertilizer know-how. Program objectives include the development of new fertilizers, as well as expanding the use of current or modified fertilizer materials. Special emphasis is placed on developing more effective fertilizers for food crops grown under tropical and subtropical conditions using, where technically or economically feasible, indigenous raw materials and production capacities.

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FERTILIZER WORLD WATCH

Fertilizer is a basic input in the food production chain. While other factors, particularly land, water, and farm machinery, also play key roles in increasing food production, expanding their availability requires long-term development strategies which are extremely costly and slow to benefit the farmer. But increased fertilizer availability and use, coupled with improved crop varieties, adequate credit and information, and an effective market demand for the output, provide the essentials for higher crop yields and farm income in a relatively short time.

It was precisely this combination of fertilizer, seed, credit, and extension information that policymakers in nation after nation employed during the food shortage of 1972-1974 to blunt the threat of increasing famine. This combination, with fertilizer as an integral part, is likely to receive even greater attention in the future as the battle to ward off starvation intensifies and the struggle to increase and distribute rural income more equitably expands. As important as fertilizer is in increasing food production, the developing countries are only now beginning to utilize fertilizer as key input in agricultural development. As recently as 1976, the developing countries with 70% of the world's population, consumed only 23% of the total fertilizer used in the world and produced as a group—only two-thirds of what they consumed.

This disparity may continue to grow unless major efforts are made by the developing countries to intensify their investments in fertilizer production, marketing, and use. Recent estimates on fertilizer use made in a report of The United Nations Industrial Development Organization (UNIDO) suggest that world fertilizer nutrient consumption will increase from 81.7 million tons in 1975 to 263 million tons by the year 2000. Using the Lima Declaration of 1975 as a guideline for Third World development strategies, UNIDO states that 40% of world fertilizer consumption by the year 2000 needs to be in the developing countries and that these same nations—as a group—should be self-sufficient in nitrogen and phosphate production by that time. The realism of these figures can be debated. The need, however, to step up efforts to promote more intensive and extensive use of fertilizer in food-deficit developing countries seems to be beyond question.

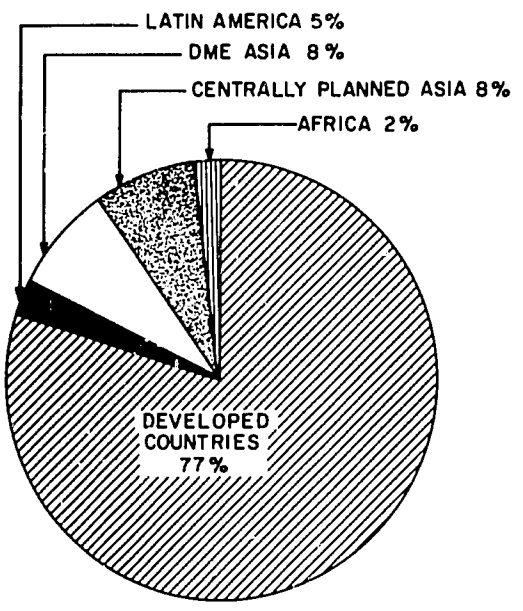
Today, there exist serious constraints at the farm level which are holding back efforts to expand agricultural productivity closer to its potential in developing countries. This lag between actual and potential can be explained in large part by the varying abilities of farmers to accept the risks involved in agricultural experimentation and operation in more complex systems of commercial agriculture. For example, the farmer who uses recommended quantities of fertilizer, particularly on food crops, assumes greater risks, particularly if water availability is unpredictable and beyond his control; if crop response to fertilizer (particularly phosphate, potash, and micronutrients) is questionable or unknown; if credit and needed inputs are expensive and/or difficult to get; and if the price the farmer received for his farm products does not permit him to realize profit.

It was the prevailing opinion in the late 1950's and 1960's that sufficient information and expertise on fertilizer use existed in the high-income countries and that the problem of low crop yields in the developing countries could be readily solved by applying the available knowledge. The experiences of the 1970's show this not to be the case. Fertilizers and application methods which performed efficiently and economically in the temperate zones (where they were developed) failed to achieve the same record in many countries of the tropics and subtropics. Problems related to the nature of tropical soils and climates, lack of fertilizer-responsive varieties, and underdeveloped transportation, distribution, handling, and storage systems all worked against expanded fertilizer use.

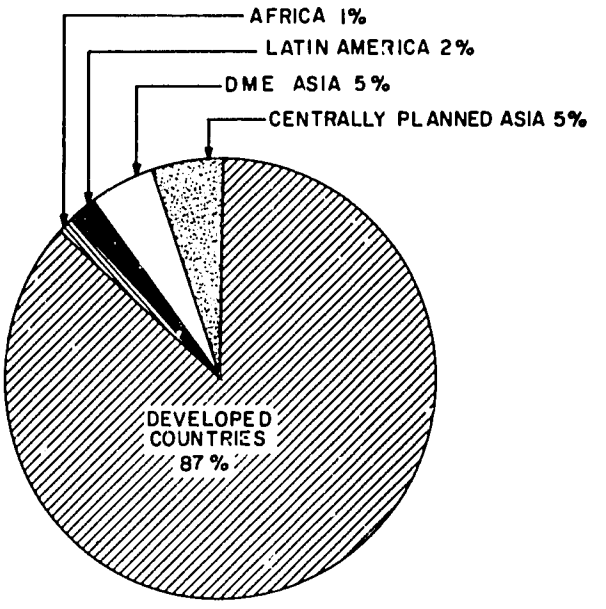
Many attempts to achieve greater national self-sufficiency in fertilizer production have not led to lower cost finished fertilizers nor net savings in foreign exchange; often this outcome can be attributed to the transfer of inappropriate fertilizer technology. Present production methods for conventional fertilizers are based upon the capital-intensive technology of high-income countries where investment capital and skilled manpower are more available. Much of this technology is energy intensive. Further, modern plants have large outputs which require considerable logistic skills to bring in needed materials and handle finished products.

Finally, time and traditional resistance to change are critical factors affecting efforts to modernize agricultural systems in the developing countries. The agricultural support services available to the high-income countries were assembled over many decades. The developing countries face a far more difficult challenge: they must transform their agriculture rapidly and in the face of mounting population pressures. Such a task needs the efforts of scientific men and women of good will the world over.

DISTRIBUTION - WORLD FERTILIZER CONSUMPTION AND PRODUCTION, 1976



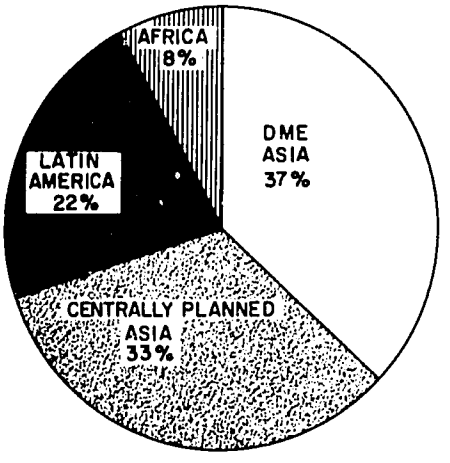
CONSUMPTION



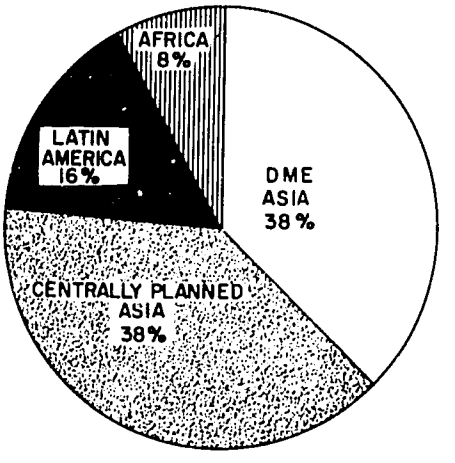
PRODUCTION

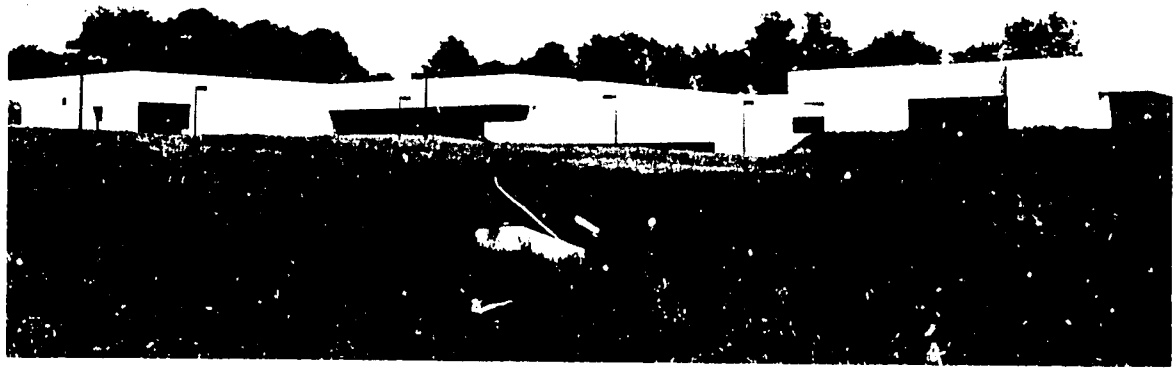
DISTRIBUTION - DEVELOPING COUNTRY FERTILIZER CONSUMPTION AND PRODUCTION, 1976

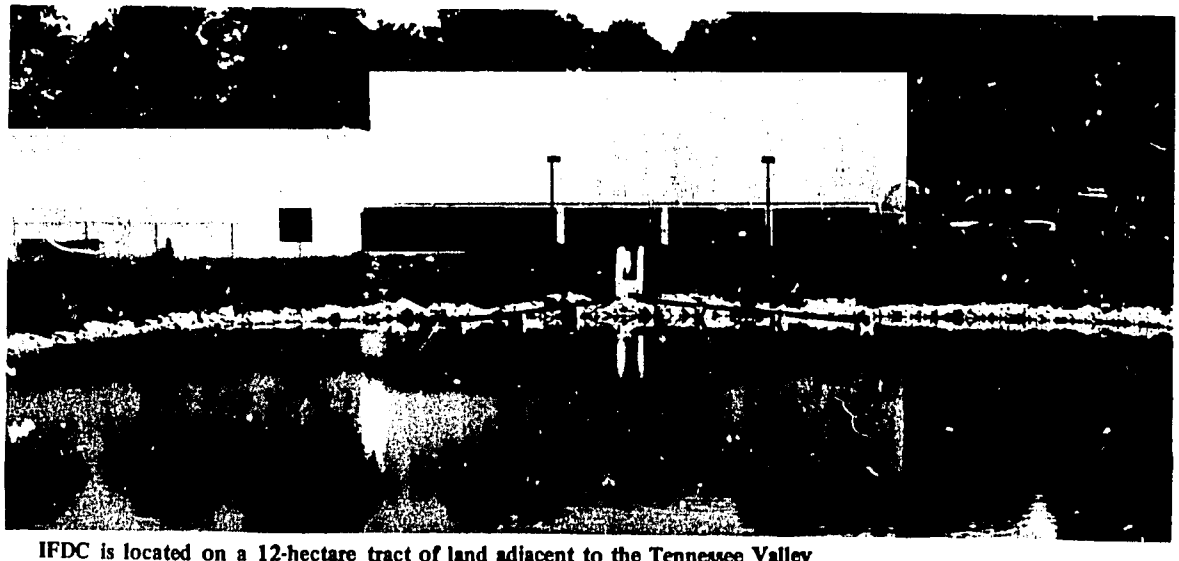
CONSUMPTION



PRODUCTION







IFDC is located on a 12-hectare tract of land adjacent to the Tennessee Valley Authority National Fertilizer Development Center. IFDC has two buildings at its Muscle Shoals Headquarters. The facility was built through a grant from the United States Agency for International Development.

ADMINISTRATIVE REPORT

Purpose and Objectives

The International Fertilizer Development Center (IFDC) is dedicated to increasing agricultural productivity in developing countries through the use of improved fertilizers and fertilizer know-how. Program objectives include the development of new fertilizers, as well as expanding the use of current or modified fertilizer materials. Special emphasis is placed on developing more effective fertilizer materials for food crops grown under tropical or subtropical conditions and, where technically or economically feasible, using indigenous raw materials and production capacities.

Organization and Staffing

IFDC is organized into an administrative group and three operating divisions—Fertilizer Technology, Agro-Economic, and Outreach—which have the responsibility for executing IFDC programs. Interdisciplinary (and interdivisional) task teams act as advisory groups on research directions for specific program areas. Administrative functions related to staff recruiting, equipment specification, and acquisition and building construction made heavy demands on staff time during 1977. During this year, the number of employees grew from 60 to 100. New directors for the Agro-Economic and Outreach Divisions were appointed. In addition, four new members were named to the IFDC Board of Directors bringing the total number of members to nine.

Legal Status

On March 14, 1977, President Carter signed an executive order designating IFDC as a public international organization under U.S. laws. This designation entitles IFDC "... to enjoy the privileges, exemptions, and immunities conferred by the *International Immunities Act*." a status sought by IFDC since its inception in late 1974.

Program Development and Activity

IFDC programs continue to develop along two general directions: fertilizer research and development and market development assistance. In the area of research, much of the planned activity still awaited full staffing complements and final equipping of laboratory and pilot-plant facilities. Research activities carried out in 1977 included soil science research in phosphorus and nitrogen and laboratory-scale fertilizer technology studies, especially in granulations of phosphate rock and soluble salts. IFDC staff members continued to extend market development assistance through technical assistance missions, training programs, and participation in fertilizer-related meetings, seminars, and conferences held in the developing countries and elsewhere.

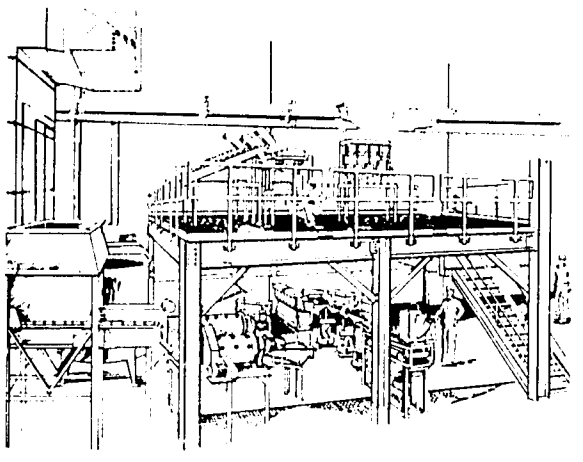
New Collaborative Agreements

A number of collaborative agreements with international and national organizations led to the launching of several cooperative projects by the end of 1977. Several staff members were outposted in the developing countries as part of these projects.

IFDC-Centro Internacional de Agricultura Tropical (CIAT)—As part of a collaborative IFDC-CIAT research project on phosphate fertilization of tropical soils in Latin America, IFDC soil scientists, Dr. William Fenster and Dr. Alfredo Leon, were stationed at CIAT in Cali, Colombia, in late 1977. The project, financed for the initial 2 years of operation through a grant from Canada's International Development Research Centre (IDRC), is an extension of IFDC research on the mechanisms affecting the rate of dissolution and residual availability of phosphorus from a variety of P sources used on acid soils of Latin America.

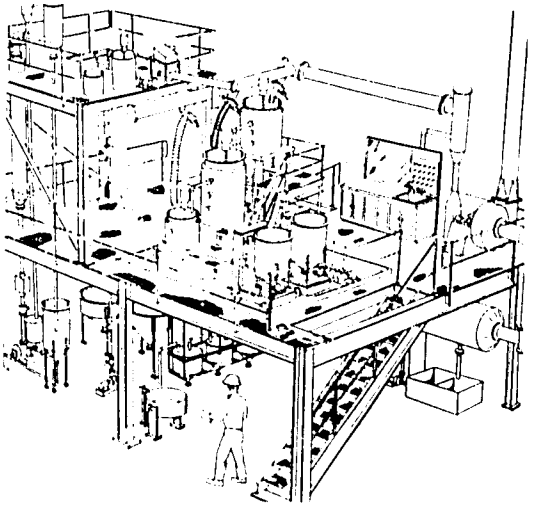
IFDC-International Rice Research Institute (IRRI)–A joint IFDC-IRRI research program aimed at developing and introducing more effective nitrogen fertilizer materials and management practices for lowland rice-growing areas was agreed upon in 1977. As part of this program, IFDC outposted Dr. Eric Craswell, IFDC Soil Scientist, at IRRI for a 2-year period beginning in January 1978. Additional funding is being sought by IFDC-IRRI so that a more intensive and integrated program of research–basic to applied–can be developed with the goal of increasing the efficiency of currently used nitrogen fertilizers used on rice.

IFDC-Korean Institute of Science and Technology (KIST)–IFDC and KIST entered into a cooperative research project to develop a controlled-release fertilizer based on urea with nutrient-release characteristics that more closely match the needs of rice varieties common to Korea and other Asian countries. KIST is testing indigenous materials for use as sealants in controlled-release nitrogen fertilizers.

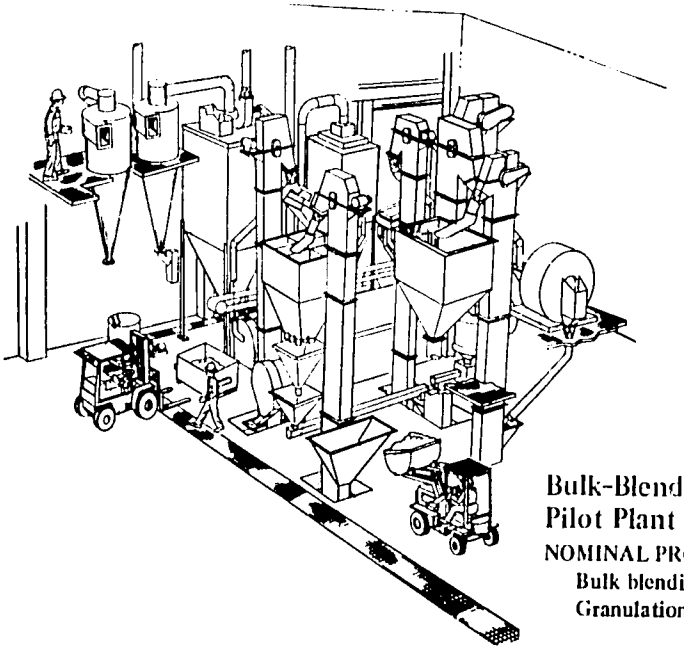


Phosphate Beneficiation Pilot Plant
NOMINAL PRODUCTION RATES

Primary crushing	1,000 kg/hour rock
Flotation	100 kg/hour ground rock



Wet-Process Phosphoric Acid/
Nitric Phosphate Pilot Plant
Nominal production rates 10 kg/hour rock feed



Bulk-Blending/Granulation
Pilot Plant
NOMINAL PRODUCTION RATES

Bulk blending	1,000-5,000 kg/hour
Granulation	200-1,000 kg/hour

IFDC PILOT PLANTS

FERTILIZER TECHNOLOGY RESEARCH AND DEVELOPMENT

Engineering research at IFDC is directed at helping to develop more appropriate technology for the resources of developing countries. An important tool assisting IFDC researchers is the new physical research facility designed to evaluate many different routes to producing chemical fertilizers better suited to the tropics and subtropics. IFDC technologists hope to develop and improve process operations, produce materials for agronomic testing, and provide training opportunities for individuals from other organizations.

Pilot Plants and Laboratory Capabilities

Three key pilot plants–crushing/grinding/beneficiation, bulk-blending/granulation, and wet-process phosphoric acid/nitric phosphate–are being established initially. Each plant is designed for maximum flexibility to vary process conditions. During 1977, IFDC engineers worked on pilot-plant designs, equipment and plant structure specifications, procurement, and preparation of the engineering research building for pilot-plant installations. In addition, an active and continuing in-service staff training program on fertilizer process engineering was initiated in 1977.

Wet/Dry Beneficiation Plant–When the pilot-plant facilities are completed in 1978, IFDC will have an operating beneficiation research facility capable of generating cost and process data for upgrading phosphate rocks of many types. It will also afford an opportunity for training activities. This plant is designed for use in upgrading phosphate rocks of many types and can handle almost all process operations– from simple to complex. This unit is designed to be adaptable for new technology developed from laboratory process studies. Beginning in 1977, much staff time has been devoted to the design of the sample preparation laboratory, the crushing and grinding area, and the wet-beneficiation pilot plant.

Bulk-Blending/Granulation Plant–IFDC considers the technology of producing and using solid fertilizers to be most relevant to tropical and subtropical areas. The bulk-blending/ granulation pilot plant is capable of producing many different granular fertilizer products–conventional and experimental–for testing. It has design features which allow reliable extrapolation of cost requirements to commercial-scale manufacturing. It also has been designed to serve as a working model for training programs in process engineering, plant operation and maintenance, and bulk blending and bagging. Startup is planned for August 1978. During 1977, laboratory- and intermediate-scale granulation work was initiated with rented equipment. Two areas of research were especially promising–minigranulation of materials like phosphate rock and granulation of soluble salts such as ammonium sulfate or potassium chloride.

Wet-Process Phosphoric Acid Plant–IFDC is developing a comprehensive research program to carry out studies using phosphate rock or concentrates for production of wet-process phosphoric acid. In addition to laboratory-scale equipment, a small pilot plant is planned to generate information on the behavior of different feedstocks in the manufacture of phosphoric acid and nitric phosphates. This unit is designed for maximum flexibility to simulate dihydrate, hemihydrate, hemihydrate-dihydrate, and nitric acid-based processes. This unit serves as a link between the beneficiation and granulation pilot plants.

Laboratories--IFDC has developed strong analytical instrumentation capabilities. In the Agro-Economic Division there are several major pieces of scientific instrumentation. The

auto analyzer is used to determine the concentration of ammonia, urea, nitrate, or nitrite in liquid samples. Qualitative and quantitative analyses of gas mixtures are carried out on a gas chromatograph. Elemental analyses are performed on the atomic absorption spectrometer. The isotope mass spectrometer is used to determine the percentage of ^{15}N in samples resulting from experiments with tagged ^{15}N fertilizer. In the near future an instrument will be obtained to measure the activity level of radioactive samples resulting from experiments using radioactive tagging. The Technology Division also has major instrumentation. A computer controlled X-ray fluorescence spectrometer is used for qualitatitive and quantitative elemental analysis of liquid and solid samples. In the other instrument laboratories IFDC has equipment to do qualitative and quantitative analyses of liquid and gas samples. In addition to this equipment, IFDC will obtain an electron microscope, an X-ray diffraction system, and some thermal analysis equipment in 1978.

Growth Chambers and Greenhouse--Since IFDC is situated in a temperate climate, facilities simulating tropical environments are necessary for preliminary agronomic testing. Growth chambers have been installed capable of varying temperature, humidity, and light. In the IFDC greenhouse, several cycles of agronomic experiments have already been completed with maize (phosphorus program) and rice (nitrogen program). Promising fertilizers and application methods are being moved to testing sites in developing countries, on and off experiment stations.

PHOSPHORUS RESEARCH

The Problem

Many soils throughout the world are naturally deficient in phosphorus. Many of the tropical soils (ultisols and oxisols) are severely phosphorus deficient, and the application rates of conventional phosphorus materials required to obtain good yields are extremely high. It may be possible to use less costly and indigenous phosphate sources to provide adequate sources of phosphorus for the plant, depending on the chemistry and acidity of a particular soil.

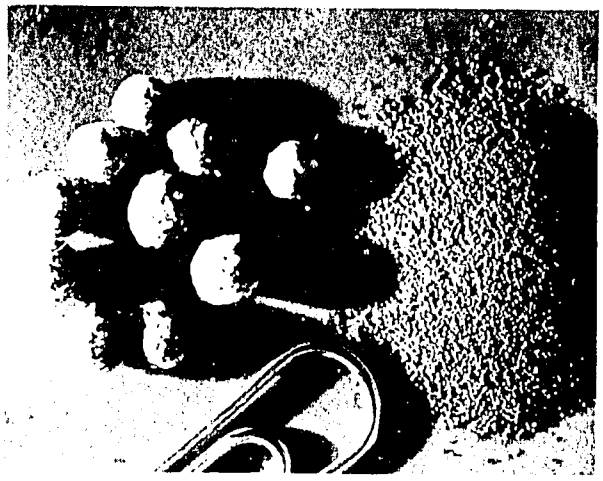
Suitability of Conventional Phosphate Fertilizers–While current high-analysis, highly water-soluble, and citrate-soluble phosphates are effective on large cropping areas in the tropics and subtropics, many of these materials also possess serious drawbacks when viewed from the perspective of developing countries. First, conventional phosphate production facilities are capital and energy intensive–serious drawbacks for capital- and energy-deficient countries. Second, with some of the concentrated P fertilizers–diammonium phosphate (DAP), monoammonium phosphate (MAP), and triple superphosphate (TSP), crop utilization of phosphorus is extremely inefficient due to the rapid fixation which occurs in many tropical soils.

Future Availability of Raw Materials–Phosphate rock deposits are distributed widely throughout the world. While total reserves appear to be ample to meet global needs in the foreseeable future, only 20% to 25% of the world's known reserves can be economically used with present mining and beneficiation technology. The remaining 75%-80% is considered economically unavailable under present price and technological conditions. Beyond that, the technology used to mine and beneficiate phosphate ores is extremely wasteful. It is common to discard up to 50% of the total P_2O_5 present in the ore during beneficiation and processing. Currently, major commercial mining activities are restricted to a few deposits. These easily minable deposits are found mainly in the United States (Florida and North Carolina), North Africa (Morocco and Tunisia), and the U.S.S.R. (Kola). Barring new discoveries of high-grade ore deposits, the development of more efficient (resource-saving) technology for beneficiation or a relaxation of environmental regulations, mining operations in Florida will soon have to shift to lower-grade rock. Shifts have already occurred in the Kola deposits resulting in the U.S.S.R. contracting for large tonnages of rock from Morocco.

Mining and Beneficiation Methods–The problems associated with the mining and beneficiation of phosphate ores, coupled with prevailing rates of depletion of high-grade deposits, are becoming matters of increasing concern because of the potential effects of phosphate rock shortages on the price and availability of future phosphate fertilizers. Unless new technology is developed to use many of the phosphate rock deposits currently unsuitable for commercial exploitation, the cost of phosphate fertilizers could increase sharply over the next few years. Further, the concentration in supply sources creates the possibility of cartel control and price manipulation.

IFDC Phosphorus Program

The IFDC phosphorus research program is oriented toward assisting developing countries to make better use of indigenous resources while at the same time developing a range of phosphate fertilizers for optimum agronomic performance for the environmental conditions encountered in the developing countries. IFDC is placing a major emphasis on the development of phosphate materials that are compatible with developing country resources, financial capabilities, and transportation, storage, and distribution systems. This effort requires a high degree of flexibility in product preparation and testing.



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Fertilizer Raw Materials Data File

IFDC continued to work in 1977 on its raw materials data file focusing initially on phosphate rock reserves. This data package, to eventually include information on phosphate, potash, and sulfur, will contain information on the location of deposits; detailed mineralogical information on the extent and quality of deposits; current exploitation methods and uses; published literature references; and, where possible, a technical evaluation of deposits. A data package of this type is needed to identify areas of potential research on fertilizer raw materials.

Phosphate Rock for Direct Application

The use of highly reactive phosphate rock for direct application instead of soluble P fertilizer is attractive for several reasons: capital and operating requirements are relatively small and the technology is simple and can be labor intensive. Historically, phosphate rock for direct application has been a subject of controversy due to the unpredictable value of the material in agriculture. Much of this controversy stemmed from a lack of understanding that phosphate rocks differed widely in their reactivity or suitability for use in direct application. It has now been established that highly reactive, finely ground phosphate rocks can, in soils with high phosphorus fixation capacity, approach the agronomic effectiveness of soluble P fertilizers, especially if residual crop response is considered.

Improving the Handling Characteristics–One of the main objections to using even highly reactive phosphate rock directly is its dusty nature when processed to the finely divided state (<200-mesh [Tyler]), which is essential to ensuring high phosphorus availability to the crop. IFDC is looking at ways to improve the physical characteristics of phosphate rock for direct application without sacrificing agronomic effectiveness. Several approaches were evaluated during 1977. Minigranules of phosphate rock and other materials were made in bench-scale equipment, and products were tested by the Agro-Economic Division. North Carolina (USA) and Sechura (Peru) rocks were being used, both being classed as highly reactive materials for direct application. Water solutions of magnesium sulfate, potassium chloride, and urea were used for binding divided rock particles. The physical properties of the minigranulated material suggest that it can be handled and stored without excessive dust problems. Preliminary greenhouse tests indicate that the minigranules have similar agronomic characteristics to finely divided phosphate rock. Larger-scale tests of handling and application are now needed.

Another means of minimizing the dust problem and still maintaining good agronomic performance is to treat the finely divided rock with a dust suppressant or with a suspending agent. IFDC, in collaboration with TVA researchers, has a method of placing finely divided phosphate rock in suspension which results in less than a 5% increase in volume, but remains in suspension for at least 48 hours. This method of application may prove useful in areas close to where the rock is ground and where large areas are treated at one time.

Increasing Phosphorus Availability–Preliminary tests were also carried out using acids such as phosphoric, sulfuric, nitric, and hydrochloric as binders to promote granulation as well as produce some portion of the phosphate product in an available form. While much more work is needed, this approach may prove useful in increasing the agronomic suitability of rocks found in many developing countries. Perhaps as important, the use of an acid binder potentially allows minigranulation to be carried out without the need for a drying step (or only requiring minimum drying). This could be a significant advantage in fuel-deficient countries, especially where byproduct acid is available.

Specialty Phosphates

Specialty phosphates can be prepared from a variety of raw materials and represent levels of technology between direct application of phosphate rock and conventional

chemical fertilizer technology. Some factors that may encourage the use of these types of materials are properties inherent in many indigenous raw materials (e.g., chemical composition, low reactivity, low grade), agronomic situation (e.g., soil, climate, crop), and transportation problems.

Thermal Methods–One type of specialty phosphate is a chemically, thermally altered phosphate having low water solubility and varying degrees of P availability as measured by solubility in neutral ammonium citrate. Although thermal phosphates require energy-intensive processing and are inferior to modern water-soluble materials in terms of P_2O_5 content, they stand to offer certain benefits in that low grade, low reactivity, and unusual composition rocks may be utilized. Also, the slow-release characteristics and retained contents of secondary and micronutrients may enhance the usefulness of thermal phosphates for some tropical areas. A preliminary study of thermally treated phosphate rock (Rhenania phosphate) carried out at IFDC in 1977 indicates that Rhenania phosphate was more effective in supplying water-soluble phosphorus in soils with high phosphorus-fixation tendencies than concentrated superphosphate. It appears that this material should be a good phosphorus source for those tropical soils with relatively high P-retention capacity, providing its cost can be competitive.

Fermentation Processes–As an alternative to the thermal processes described above, IFDC has begun some preliminary work on modification of rock availability using various fermentation products. The basic principle is that waste agricultural products (e.g., cassava, rice straw, sorghum stalks, cocoa wastes) are fermented to produce organic acids (citric, lactic, acetic) which can be mixed with rock to yield a product with increased phosphate availability. This fermentation might occur at individual farms or at a cooperative. The project is being done for IFDC on a contract with the University of North Alabama; only preliminary data were available at the end of 1977.

Wet-Process Phosphoric Acid Research

The production of phosphoric acid for fertilizer via the wet-process "gypsum" method has been practiced commercially for many years. Most existing wet-process technology is designed to use calcium-type high-grade phosphate ores, available only in a relatively few places. The basic production scheme involves acidulating phosphate rock with sulfuric acid and filtering off the resulting calcium sulfate (gypsum) and other insoluble impurities. A variety of processes are used to produce phosphoric acid with concentrations ranging from 30% to over 50% P_2O_5. The quality of the resulting acid is heavily dependent on the quality of the feedstock.

Indigenous Raw Materials as Feedstocks–Considerable interest exists in developing countries possessing phosphate ore deposits of problem types (e.g. high in silica, iron and aluminum, or carbonate) for the development of process modifications and/or operating techniques to permit satisfactory and economical use of these ores. IFDC is expanding its research capability to carry out studies using phosphate rock or concentrates for production of wet-process phosphoric acid. During 1977 a bench-scale unit was installed and trial runs were carried out. In normal operation (without acid concentration) a 30% P_2O_5 can be made. With concentration, a 54% P_2O_5 acid can be made. This unit will be valuable in carrying out comparative tests of problem ores. It also will serve as an excellent model for research and training.

Smaller-Scale Production Units–In addition to serving as an impartial and non-commercial information source to developing countries for technical evaluations of ore deposits, IFDC is also studying the economic feasibility of developing small-scale, less capital-intensive phosphoric acid production units which can be constructed at a fraction of the cost of conventional-scale units normally built today. Such smaller-scale units

(5-10 tons per day) may offer a more appropriate alternative to importing or building 600-ton-per-day phosphoric acid production units, particularly for land-locked countries where transportation/distribution systems are underdeveloped; market demand is characterized by isolated pockets of fertilizer use; and small deposits of phosphate rock are present.

Recovery of P_2O_5 from Waste Materials

IFDC has been asked to tackle a major problem existing in the Taiba mine in Senegal, where phosphate rock is mined and processed. There is already about 20 million tons of slimes on hand. With an annual production of 2 million tons per year of byproduct slimes, its disposal is becoming a serious problem threatening future production. A small sample of the slimes was received for exploratory studies, and a proposal has been submitted to Compagnie Senegalaise des Phosphates de Taiba (CSPT) on a potential method to economically recover most of the P_2O_5 found in these slimes.

Soil Science Research in Phosphorus

The key to development of more efficient phosphate fertilizers for acidic tropical soils is the understanding of basic phosphate reactions in the soil and the factors which control them. During 1977, IFDC carried out laboratory and greenhouse studies directed at developing information needed for the rational design of improved fertilizers for phosphorus-deficient soils found in the developing countries. In the area of soil chemistry studies, research in 1977 produced considerable information on the factors that affect the dissolution of phosphate rocks in soils. Such information bridges the gap between the characterization of rock and the results from agronomic trials. Comparisons were made of laboratory methods for predicting the agronomic potential of various rocks for direct application. A simple chemical method was developed for evaluating the potential of granulated phosphate rock for direct application. This new promising method of mixing H-resin and sand with granulated phosphate rock revealed high correlation coefficients of predictability. Previous field research in Colombia led to the development of the collaborative IFDC-CIAT phosphorus research project mentioned earlier. In addition to field research in Colombia during 1977, IFDC soil scientists and contract researchers carried out laboratory and greenhouse research at IFDC to determine how agronomic effectiveness of different phosphorus fertilizer materials is affected by soil properties, crop type, and levels of management. Experiments were initiated to evaluate the initial and residual phosphorus availability of phosphate materials with a range of granulation treatments.

Economic Evaluation of Alternative Sources of Phosphorus

The increasing costs associated with the extraction, processing, and distribution of P_2O_5 and the problems of "phosphorus fixation" associated with the use of soluble P fertilizers on certain tropical soils stand to deprive large tropical farming areas of adequate fertilization for productive agriculture. During 1977 IFDC Agro-Economic researchers developed a framework to evaluate various sources of phosphate. The model captures the initial season response to fertilizer as well as the residual value of different materials such as TSP and phosphate rock for direct application. Preliminary economic analyses indicate that the initial production cost advantages which a unit of P_2O_5 has as phosphate rock over the more concentrated, highly processed TSP, can be eroded away where distribution costs represent a large part of actual farm-gate prices. Thus, only market areas relatively close to sources of reactive phosphate rocks appear economical in today's market situation. However, preliminary studies indicate that, as the cost of a unit of P_2O_5 trends upward, the cost advantage of phosphate rock for direct application improves relative to materials such as TSP. Research on the economics of using various P fertilizer materials is receiving increased attention in the 1978 program year.

NITROGEN RESEARCH

The Problem

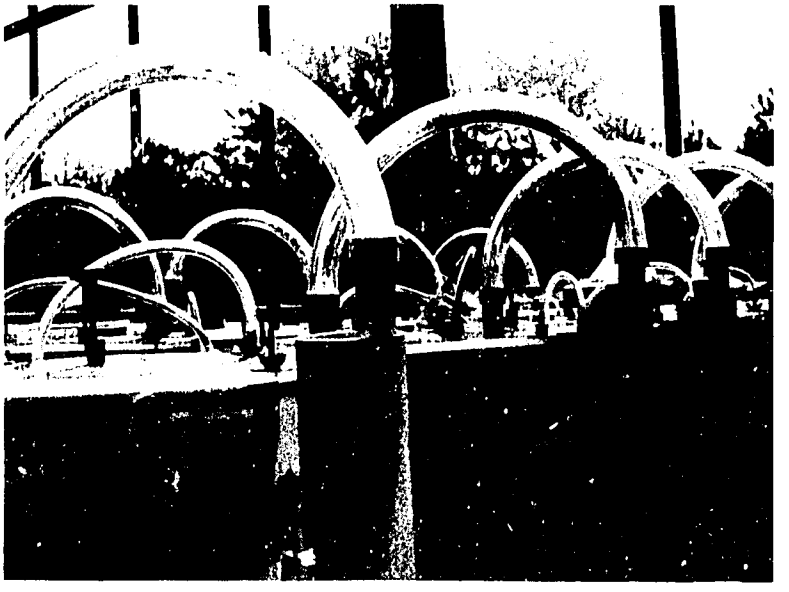
Adequate supplies of nitrogenous fertilizers are essential to meeting the food requirements of the world's expanding population. Food crop demand for nitrogen has long exceeded the ability of known natural biological fixation sources of nitrogen to meet needs. There is a great need for fertilizer nitrogen in the developing countries. Yet, forces exist that are holding back the expanded use. Farmers in developing countries face high real costs when using these fertilizers due, first to the high level of nitrogen loss occurring when currently available materials are used in tropical and subtropical agriculture and, second, because of the rising costs associated with producing and distributing nitrogen fertilizers. Currently, most of the world's nitrogen fertilizers are manufactured using ammonia made in the Haber-Bosch process developed in the early part of this century. This process utilizes nitrogen from the air and hydrogen from natural gas, naphtha, fuel oil, or coal in combination with steam. Natural gas is the dominant raw material providing 70% of the world hydrocarbon source for ammonia (95% in the United States). This inextricable link between the energy situation and the production of nitrogen fertilizers has been a subject of concern in recent years. Fears of impending shortages of natural gas, fuel oil, and naphtha, and upward spiraling prices have raised questions about the future availability of nitrogen to feed expanding agricultural production. Further, with prilled urea, the prevailing fertilizer material used in the developing countries, and the general application practice of broadcasting with only minimal incorporation into the soil, nitrogen losses in the order of 40%-70% of the actual nutrient applied often occur. Under extreme conditions nitrogen losses may be even greater.

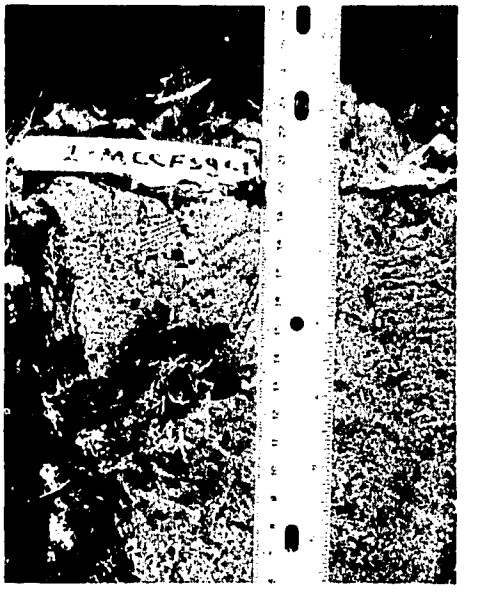
IFDC Nitrogen Program

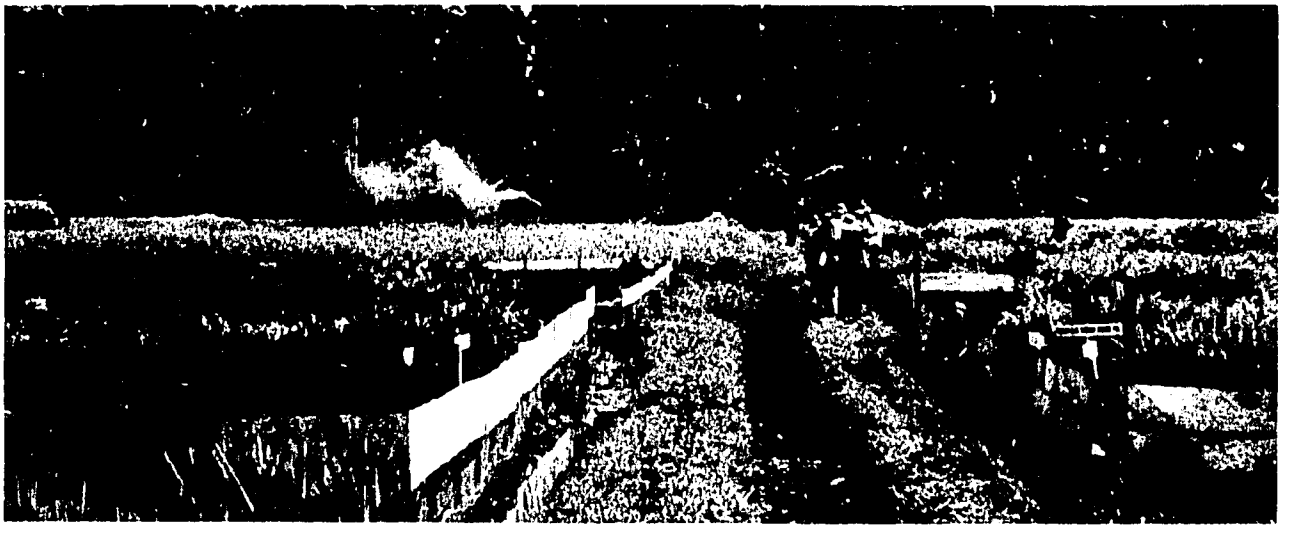
Although urea is a high-analysis, relatively inexpensive source of nitrogen, it is not a perfect material for the conditions encountered in many developing countries. Urea poses problems in handling, storage, and use in hot, humid, or arid conditions. Further, due to undesired chemical reactions, conventional urea in its common forms (prilled or granular) cannot be used in bulk blends with TSP, a major phosphorus material used in crop production. It is unlikely that a new nitrogen material will be developed over the next 20 years that will replace the major fertilizers—urea, ammonium sulfate, and ammonium nitrate—now being used in developing countries. Thus, a major portion of IFDC research on nitrogen is on ways to modify existing materials and methods to improve uptake of fertilizer nitrogen by plants. During 1977, IFDC scientists focused their attention on nitrogen losses in lowland rice cultivation primarily in Asia. Specific attention has been given to the study of losses via ammonia volatilization. Research done to date in the tropics and subtropics has not produced a full understanding of the nitrogen/soil/water/plant interactions under various environmental conditions. Gaining such knowledge and relating it to losses occurring with the use of present-day fertilizers are basic to IFDC efforts to improve nitrogen efficiency. Research at Headquarters is integrated with field experiments at various developing country locations in collaboration with national and international institutions. The initial crop focus is on rice, although research on other food crops is planned.

Emphasis on Modifying Urea Materials and Application Methods

Given the dominance of urea from a use and production standpoint in developing countries, a major portion of IFDC's nitrogen program is directed toward developing and transferring technology to improve its use efficiency and handling properties. Two general approaches are being pursued: controlling nutrient release through coatings and the development of materials and methods for deep (point) placement of nitrogen, either by







A major portion of IFDC's nitrogen program is directed toward developing and transferring technology to improve the use efficiency and handling properties of urea. Two general approaches are being pursued: controlling nutrient release through coatings and the development of materials and methods for deep (point) placement of nitrogen.

hand or through the use of simple equipment; the combination of point placement and controlled release is also being evaluated in agronomic experiments. This material is stronger than prilled material and can be bulk blended with DAP and MAP. The particle size of granular urea can be adjusted from normal granules to supergranules using modified process equipment. Granular urea is also an important modification over currently traded prilled urea and is an improved substrate for coating with sulfur and other substances to obtain controlled-release materials.

Controlling Nutrient Release—The best known experimental controlled-release fertilizer currently available for use is TVA's sulfur-coated urea (SCU). This material, which is free flowing and nonhygroscopic, goes a considerable way toward meeting the needs for a single application material for crops having a long growing season. For rice, SCU is applied in one broadcast treatment at the time of final harrowing of the paddy and may be particularly useful for the typical Asian farmer who has problems of water and fertilizer management. Additionally, a coated material like SCU, unlike urea, can be mixed with TSP for use in bulk blends. Although the technology of coating granular urea with sulfur is quite developed, the coating process may add as much as 30% increase in price over basic urea. Further, the use of sulfur in the coating presents a problem for many developing countries which lack adequate quantities of this raw material. IFDC researchers are looking at ways of improving the efficiency of urea through variations in granule size, surface characteristics, and surface coatings.

Materials for Deep Placement—Researchers are looking for economical ways to place urea beneath the soil surface as a method of reducing losses. One approach, an evolution of the Japanese mudball, is the production of urea supergranules and/or briquettes. The supergranule may also be a more economic size to apply a coating for controlled release, thus, achieving deep placement and controlled release in a single particle. Another approach is to put the urea into a solution (mix with water 1:1) and inject the solution into the reduced soil zone with a simple applicator. This approach, which eliminates the volatilization process, may become a viable method to improve nitrogen efficiency if an applicator can be produced at a price within the purchasing power of the small farmer. IFDC begins testing of a prototype injector at IRRI in 1978.

Producing Modified Urea Materials

IFDC technologists are providing a number of experimental nitrogen materials for agronomic screening in combination with various placement methods. In 1977, because pilot-plant production units were still under construction, IFDC was not able to produce sufficient materials for widespread testing. IFDC has assembled a small bench-scale coating unit for laboratory studies of various coatings to be applied to supergranules and to more conventional-sized urea. To supplement current IFDC capability, a contract was initiated with KIST to develop a superior coated nitrogen fertilizer having the property of a triggered nitrogen-release mechanism to better match crop needs, especially paddy rice. KIST is testing substitute coatings and sealants for SCU, such as locally available byproduct waxes. In 1978, IFDC will have pilot-plant facilities to produce larger quantities of modified urea materials for testing.

Improved Use of Byproduct Nitrogen Materials

Granulation of soluble salts has been tried in the past with poor results, mainly due to the weakness of the granulated product. During 1977, IFDC developed a process in the laboratory which produces strong granules of soluble salts such as ammonium sulfate and potash. In the case of nitrogen, the potential application of this process would be to granulate byproduct ammonium sulfate generated, e.g., from a caprolactam (plastics) plant. From this byproduct material a good quality product was made that appears to be well suited for bulk blending or direct application. An application for a patent on the

granulation of soluble salts has been filed by IFDC. Pilot-plant operations to develop engineering information are planned for 1978 to substantiate laboratory results.

Soil Science Research in Nitrogen

Basic soils research is underway to assess quantitatively the importance of the different mechanisms of nitrogen loss. Three mechanisms– denitrification, ammonia volatilization, and leaching–are being studied. This research is directed toward providing IFDC technologists with a rational basis for the development of new and more efficient nitrogen fertilizers tailored to the tropical and subtropical conditions found in many developing countries. Researchers to date identify three primary methods of improving nitrogen uptake by rice. These are: (1) split applications so that nitrogen is applied during periods of peak crop demand and, thus, minimizing the quantity of fertilizer susceptible to losses; (2) deep placement of the fertilizer nitrogen in the active rooting zone of the plant and beneath the oxidized layers; and (3) various coatings and inhibitors to control the release or availability of nitrogen in the soil to match more closely the nitrogen needs of the plant. All of these methods have some disadvantages. Split applications and ways to place sufficient nitrogen in the reduced plowed layer have required extra labor–a discouraging factor, in many cases, for farmer adoption. Coated materials like SCU, while more effective than straight urea, are more expensive to produce and may require raw materials which are not found in developing countries. Such factors may restrict the commercial production and use of coated materials.

IFDC's approach of coating a urea supergranule (1-3 grams) with sulfur (SCSG) or other materials for deep placement offers a number of potential advantages as a concept over past methods. First, SCSGs provide sufficient nitrogen in a single application to meet the needs of the rice crop. Secondly, the combination of controlled release and deep placement substantially improves the use efficiency of the fertilizer nitrogen applied by reducing losses caused by leaching and volatilization. Finally, the cost of coating a larger urea granule may be less per unit of weight than with a smaller granule. In a 1977 greenhouse experiment a variety of conventional and experimental fertilizers were used for rice grown in two soils subjected to both continuous and intermittent flooding. The greenhouse results demonstrated a dramatic increase in fertilizer nitrogen recovery by the plant (over split application of urea) when deep placement and controlled release (as with the SCSGs) are combined. Data from the experiments conducted in 1977 suggest that ammonia volatilization was a major mechanism of nitrogen loss. Other greenhouse and growth chamber studies suggest that urea, which, upon hydrolysis, provides its own alkalinity to promote ammonia loss, ammonia volatilization may be an important mechanism of loss when urea is broadcast on many farmers' fields.

Economic Evaluation of Modified Urea Materials

An economic evaluation of a Bangladesh experiment on the comparative agronomic performance of split applications of urea, basal application of SCU, and deep placement of urea mudballs, supergranules, and briquettes indicated that for both continuously and intermittently flooded situations, SCU had the best potential to increase the efficiency of nitrogen fertilization. In this same experiment, the nitrogen performance of urea supergranules was not statistically different to that of split applications of urea. Urea mudballs gave the poorest performance of all sources. Since the price of SCU-nitrogen is greater than that of urea-nitrogen, additional economic analysis is required to determine if SCU basal has the potential to increase economically the efficiency of nitrogen fertilization compared with split applications of urea. Further, since the data analyzed are from experiment station trials, farm-level testing is needed to determine if similar results will be obtained.

RESEARCH ON OTHER NUTRIENTS

Sulfur

The increasing incidence of sulfur deficiencies throughout the tropics combined with the declining popularity of sulfur-bearing fertilizers, such as ammonium sulfate (AS) and single superphosphate (SSP), has led IFDC to initiate a research program on ways to meet the sulfur requirements of crops grown in developing countries that have sulfur-deficient soils. During 1977, Dr. Graeme Blair, acting as an IFDC Consultant while on leave from the University of New England, Australia, prepared a literature review and position paper documenting the need and possible objectives for a research program on sulfur. This report has served as a starting point for IFDC to develop a program to evaluate and modify currently available sulfatic fertilizers to meet the needs of tropical soils and crops.

In late 1977, IFDC began planning a soil microbiology laboratory for research on sulfur and its interactions with other nutrients. Staff will be hired in 1978 to map out program directions in greater detail and to equip the laboratories. In a general sense, however, the program will include workshops and other meetings to bring sulfur researchers from developing countries together; laboratory studies to survey, identify, and, if necessary, develop more accurate methods of determining sulfur levels in soil and plant samples; laboratory and greenhouse studies on fertilizer reactions in tropical soils to ascertain the release pattern of fertilizer sulfur and its effect on soil pH and the availability of other nutrients; and field studies to determine the agronomic efficiency and residual value of various sulfur sources and the long-term consequences of various treatments on soil pH and nutrient availability.

MARKET DEVELOPMENT ASSISTANCE

At IFDC market development assistance refers to a wide range of research, technical assistance, and training activities directed toward the expansion of economically sound fertilizer sectors in developing countries.

Research Activities

Constraints on Fertilizer Use

Matching fertilizer supply with demand is only possible through a good understanding of the factors affecting farmers' decisions to adopt and use fertilizer materials. Knowledge of constraints to increased fertilizer use is necessary to develop public policies to accelerate this use. IFDC researchers are trying to thoroughly understand the forces affecting fertilizer adoption and demand in developing countries and how policy action might stimulate supply and demand. An extensive review of the literature reveals the need for an interdisciplinary approach when trying to explain or estimate fertilizer demand. IFDC has formed a research team made up of physical and social scientists who are considering the influence on fertilizer adoption and demand of a broad range of economic, social, and physical factors, including the influence of soil and agroclimatic variations. Specific research proposals for collaborative projects have been developed for Bangladesh, the Dominican Republic, Guatemala, and India. Although no official agreements were signed in 1977, IFDC staff members became involved in country-specific research discussion in several countries. In Bangladesh, a tentative agreement with the Bangladesh Rice Research Institute led in 1977 to the development and pretesting of the country-specific questionnaire, training of collaborating field personnel, and selection of testing sites. The Bangladesh Agricultural Research Council has assumed coordination for the project, which begins in 1978.

Guatemala Field Research—An IFDC Rockefeller Postdoctoral Fellow began field research in Guatemala in late 1977. How farmers reach decisions and the range of choices the farmer faces (e.g. soils, weather, prices, risk, credit, fertilizer availability, knowledge, etc.) are the focus of this research. Farmers operating under diverse conditions are being interviewed as the basis for developing a series of models which specify the factors affecting farmer decisions on the adoption and use of fertilizer and other improved practices. These models will be tested with data from a representative sample of farmers from the same area. If the models prove to be good predictors of farmer fertilizer decisions, the data will be used to develop farm-level fertilizer demand estimates for Guatemala. IFDC is receiving assistance from several Guatemalan public agriculture agencies, primarily the Institute of Agricultural Science and Technology (ICTA) and the General Directorate of Agricultural Services (DIGESA). The results of this study, to be completed in 1979, will be published in Spanish and English.

Public Policy Research

The goal of public policy research at IFDC is to evaluate the relative effectiveness and impact on economic development (including equity considerations) of different price support, subsidy, and credit programs. This research is intended to provide guidelines to policymakers who formulate fertilizer policies. During 1977, policy researchers reviewed the literature and prepared a conceptual framework for analyzing alternative policy options. IFDC researchers made contributions to a fertilizer analysis of west Africa; various IFDC seminars and training activities; and at conferences held in the Philippines, Thailand, and India on fertilizer-related issues. Several country-specific studies begin in 1978. Planned are a series of regional and national policy studies in cooperation with other international centers and national governments.

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Economic Evaluations of Fertilizer Materials and Practices

Economic evaluations of different fertilizer materials and practices provide the ultimate test of experimental ideas. IFDC researchers initiated activities in 1977 to develop an analytical framework for comparing slow nutrient-release materials such as sulfur-coated urea (normal and supergranules) with straight urea, ammonium sulfate, and ammonium nitrate. Also, a framework was needed to compare relatively insoluble phosphate fertilizers, such as finely ground phosphate rock and thermal phosphate, with more soluble materials, such as TSP and DAP; this also was developed in 1977.

Outreach Services

Three service units, each with specific responsibilities in engineering, market development and analysis, and human resource development, have been established to support technical assistance and technology transfer programs in developing countries. In responding to technical inquiries for assistance, IFDC relies on its permanent staff as well as on a host of consultants, many of whom are with TVA.

Engineering Service Unit

This unit helps identify production and distribution problems associated with the transfer and use of improved fertilizer technology, responds to requests for short-term technical assistance, and transmits information back to the research divisions on problems requiring research and development to provide solutions. In 1977, the Engineering Service Unit responded to technical inquiries from over 20 countries. In addition, this group provided technical assistance to organizations in eight countries. Such assistance took the form of IFDC teams traveling to specific countries or developing countries sending their staff to Muscle Shoals.

Market Development and Analysis Group

IFDC is rapidly becoming an important source for market development fertilizer information, analysis, and experimental materials for testing. In the information area, data are being compiled and analyzed in such areas as fertilizer plant investment, worldwide production capacity, fertilizer price trends, country inventories, raw material deposits, and fertilizer distribution and transportation costs. Future data to be gathered include agronomic response of key crops and benefit:cost analysis of fertilizer use. IFDC draws upon TVA-FAO fertilizer data files, national governments, and private sector organizations in developing this information base. In 1977, IFDC staff members were involved in market development studies covering fertilizer sectors in 13 countries. Such studies took the form of regional and national surveys. The frameworks used to analyze fertilizer sectors have varying degrees of sophistication. IFDC also sent quantities of experimental fertilizer materials to other research organizations. In 1977, a variety of nitrogen and phosphorus fertilizer materials were shipped to over 20 countries for testing. In responding to requests for fertilizer materials, IFDC provides information about the material including recommended methods of storing, handling, and using the various materials. IFDC also provides assistance on analytical methods to evaluate data from fertilizer trials.

Human Resource Development Service Unit

This unit has the responsibility of coordinating a variety of conferences, seminars, and training programs. IFDC can provide the setting for both individualized and group training programs for up to 60 persons at one time. The training center includes offices for visiting trainees, a television studio, and facilities for closed-circuit television programs, and a photographic and graphic arts department. In addition to programs

offered at Headquarters, IFDC also offers programs which are developed for delivery in cooperation with other organizations. IFDC training programs and conferences reached individuals from 18 countries during 1977. At Headquarters, the completion of the 1-year factory maintenance course for eight Bangladesh engineers and the first IFDC Distribution Seminar with 19 participants from 11 countries were the major group activities. Overseas, the Fertiliser Association of India/IFDC 1977 Seminar in New Delhi, India and the West Africa Soils Workshop, Accra, Ghana, were also important to the IFDC outreach program.

At IFDC market development assistance refers to a wide range of research, technical assistance, and training activities directed toward the expansion of economically sound fertilizer sectors in developing countries.

HIGHLIGHTS OF TECHNICAL ASSISTANCE ACTIVITIES

IFDC Regional Coordinators for Latin America, Africa, and Asia helped orchestrate 1977 program activities in each region. In responding to requests for assistance, IFDC called upon individuals from all divisions as well as from outside the Center. TVA continued to provide valuable backstopping in this endeavor.

Latin America

Colombia

Monomeros Colombo-Venezolanos, S.A.—A technical assistance team of Dr. R. T. Smith, IFDC Regional Coordinator for Latin America, and Mr. J. J. Schultz, IFDC Chemical Engineer, traveled to Barranquilla, Colombia, in early 1977 to consult with officials at MONOMEROS. IFDC assistance focused on two subjects: the utilization and installation of recently acquired used bulk-blending machinery and the development of a production and marketing program that integrates existing MONOMEROS production facilities with newly acquired equipment. IFDC assisted MONOMEROS in a program to introduce bulk blends in Colombia with the preparation of two specialty bulk blends for testing by the Colombian Coffee Federation (FEDECAFE), a major customer. Field tests by FEDECAFE indicated that up to 75% of the potash content could be supplied as potassium chloride and thereby yield potentially higher grades at lower costs than relying totally on potassium sulfate. Quality bulk blends were made using a mixture of potassium sulfate and potassium chloride.

Dominican Republic

IFDC first provided technical assistance to the Government of the Dominican Republic (GODR) in 1975 in the development of a fertilizer marketing strategy design to expand food production on small-to-medium size farms. The GODR concluded that reaching the small farmer with new farm input technology would be difficult through traditional private sector marketing channels. This situation prompted GODR to initiate a pilot-scale small farm store program in 1975. By the end of 1976, 18 stores with warehouses were in operation serving 28,000 small farmers. In 1977, the number of stores in operation was expanded to 35. By 1978, it is projected that 60,000 farmers will be served by the stores. In 1977, Dr. R. T. Smith, IFDC Regional Coordinator for Latin America, reviewed the small farm input store program for USAID, which provided loan money to the GODR to launch the program.

Ecuador

In response to a request from Fertilizantes Ecuatorianos S.A. (FERTISA) through USAID, IFDC sent Mr. J. J. Schultz and Dr. R. T. Smith to identify technical assistance requirements related to FERTISA production, marketing, and use. Recommendations were made on ways to modify existing production facilities to increase operating efficiency as well as marketing strategies to strengthen FERTISA's position in the marketing of both nationally produced and imported materials.

Uruguay

At the request of the Cooperative League of the USA (CLUSA), IFDC Regional Coordinator for Latin America, Dr. R. T. Smith and CLUSA Consultant, Mr. Harold Jordan, traveled to Uruguay in mid-1977 to assist the Cooperativa Agropecuaria Limitada de Sociedades de Fomento Rural (CALFORU) with its member fertilizer demand and supply alternatives. In 1977, CALFORU had approximately 200 local cooperative association members, half of which handled fertilizer. Since 1970, when CALFORU began to sell fertilizer to member co-ops, it has become the fourth largest distributor in

Uruguay, relying almost totally on imported materials. As of 1977, CALFORU supplied around 50% of total member demand. The remaining fertilizer demand is purchased directly, usually from Uruguayan producers. IFDC reviewed CALFORU's market situation and made recommendations regarding the management of current distribution operations. Recommendations were also made on the establishment of long-term contractual arrangements for imported materials as well as the possibilities for entering into actual production.

Africa

Senegal

IFDC is assisting the Senegalese government agency, SODEVA, with research relating to the response of peanuts (groundnuts) and millet to various levels of fertilizer in different areas of the groundnut basin of Senegal. The objective of this assistance, which was initiated in 1975 by TVA Consultant, Dr. Wesley G. Smith, is to provide the Government of Senegal with research data and analysis to recommend fertilizers to farmers on an economic basis. The research project includes farm-level trials, statistical analyses, and agro-economic interpretation of field-level trials and research data generated by other organizations, test demonstrations, and a farmer survey on fertilizer preferences.

Asia

Indonesia

The Indonesian fertilizer manufacturer, P.T. PUSRI, has embarked on a program to modernize its oldest urea fertilizer plant. IFDC, in accordance with its strong interest in the transfer of granular urea technology to Asia, sent two chemical engineers, Mr. D. R. Waggoner and Mr. M. T. Frederick, to P.T. PUSRI to provide technical assistance in the conversion of PUSRI I fertilizer plant from prilled to granular urea. Anticipated changes call for the conversion of the fertilizer finishing section to the production of granular urea utilizing the pan-granulation process. These changes will improve plant efficiency, lower maintenance costs, reduce air pollution, eliminate the need for rebuilding the prilling tower, permit production of granular urea which has superior physical properties and can be used in bulk handling and blending NPK-type fertilizers, and provide an excellent substrate for possible future controlled-release fertilizers. PUSRI engineers worked with IFDC and TVA on design parameters and equipment specifications. IFDC also provided assistance in evaluating construction bids and equipment vendors and will follow through on the installation and initial operation phase.

India

IFDC and TVA engineers worked with the Fertilizer Corporation of India (FCI) on detailed drawings and equipment specifications for a 20-ton-per-hour demonstration-scale urea ammonium phosphate plant (UAP). In addition to design specification work for the UAP plant, the FCI engineers investigated the pipe-cross reactor for potential use in FCI granulation plants (including the UAP facility) and also studied process operations for producing controlled-release coated fertilizer materials.

Nepal

Two IFDC staff members, Mr. Fred Klem, Chemical Engineer, and Mr. Bill Barnett, Civil Engineer, traveled to Nepal at the request of USAID to offer recommendations on the design of structures and appropriate bagging to protect the quality and quantity of fertilizers stored under humid conditions, methods for salvaging fertilizers that have become unsuitable because of improper handling and storage, and alternatives for transporting fertilizer to the Hills area of Nepal. The team visited with government officials and made field trips to inspect handling and storage facilities. A number of changes in building designs and bagging materials and methods were suggested.

DEVELOPMENT PLANNING ASSISTANCE

Arab States Fertilizer Study

In early 1977, two IFDC staff members, Dr. R. B. Diamond, Regional Coordinator for Africa, and Dr. D. H. Parish, Regional Coordinator for Asia, and one consultant, Dr. Harvey Stangel, participated in a fertilizer sector review in Tunisia, Algeria, Morocco, Jordan, Syria, Iraq, Kuwait, and Egypt. The study was sponsored by the United Nations Development Programme (UNDP) at the request of the Industrial Development Center of the Arab States (IDCAS) with the cooperation of UNIDO and the Arab Federation of Chemical Fertilizer Producers. The study, to be released under UNDP cover, provides a comprehensive survey of existing and proposed fertilizer production capacity in those Arab states listed. Constraints resulting in low production operating efficiency levels were identified, and recommendations were made for corrective action, particularly in the area of training. An assessment was made of the current and projected use of fertilizers by the different countries, as well as the constraints affecting agricultural development plans regarding fertilizer use. Based on this study, revised projections were made on Arab States' production available for export.

ASEAN Region Fertilizer Study

An in-depth study of the comparative economic advantages and disadvantages of alternative fertilizer supply strategies for the ASEAN region of Southeast Asia was undertaken in 1977 with national collaborators participating from Indonesia, Malaysia, and the Philippines. Five basic scenarios, using assumptions agreed upon by all study team participants, have been identified for analysis in an IFDC-developed computer model. These scenarios range from a policy of complete self-sufficiency in nitrogen and phosphorus fertilizer production for each country in the ASEAN region to situations where regional fertilizer demand can be met through either trade within the region or from sources outside the ASEAN countries. The current study is a continuation of a previous 1975 IFDC/World Bank report on the ASEAN region. The new study benefits from more current data as well as a more sophisticated economic model for analysis. Expanded considerations include the possibility of noncoastal production sites, production of NPK fertilizer by either granulation or bulk blending, the optimum timing of investment and trade expansion, and economics of scale in plant investment and production.

Economic and Technical Aspects of Fertilizer Production and Use in West Africa

This report was prepared during 1977 under a USAID contract with Michigan State University (MSU). IFDC staff members, Dr. R. B. Diamond, Regional Coordinator for Africa, and Dr. M. S. Mudahar, Economist, coauthored this report with Dr. T. Zalla of MSU. The purpose of this study was to examine the role of fertilizer in increasing agricultural production in west Africa and to assist USAID in developing a strategy for funding projects for the production and expanded use of fertilizer in the region. Recommendations were made covering a broad spectrum of agricultural development issues. The report concluded that, although the scope of increasing fertilizer use is potentially very large, it is important to remember that fertilizer is only one input in the overall agricultural development food production chain. The potential of fertilizer in increasing yields and agricultural productivity is directly related to the availability of complementary inputs such as fertilizer-responsive varieties, adequate rainfall or water, pesticides, and appropriate farming practices. Institutional support in the form of subsidies, price supports, agricultural extension, credit, and infrastructural development is needed to facilitate and expand fertilizer use. Finally, the market demand for agricultural products must be there to promote dynamic self-sustaining growth in agricultural production.

World Bank Study–FERTIMEX

FERTIMEX (formerly known as GUANOMEX), the public sector fertilizer industry of Mexico, submitted an application to The World Bank for financing of a fertilizer production facility at Lazaro Cardenas. The World Bank, as part of its evaluation of the FERTIMEX loan application, requested IFDC's assistance in evaluating projected fertilizer market potential for the production of this facility in relation to fertilizer demand trends in Mexico. Mr. John Hill, IFDC Marketing Development Specialist, prepared an evaluation of the FERTIMEX project. This facility, considered necessary to help meet Mexico's fertilizer demand in the 1980's, is scheduled to come on stream in 1981; anticipated products are DAP, compound NPK fertilizers, ammonium nitrate, and phosphoric acid. The study concluded that the products from the Lazaro Cardenas project are needed to meet the likely demand for intermediates, particularly phosphoric acid, and finished fertilizers in Mexico. IFDC's report, which helped The World Bank determine its decision on the loan request, has also led to the direct collaboration of FERTIMEX and IFDC in a more in-depth study of the fertilizer situation in Mexico. A report will be published in 1978.

TRAINING, CONFERENCES, AND SEMINARS

IFDC staff members participated in a number of training programs, workshops, and seminars during 1977. Some were staged at IFDC Headquarters, often with strong program support from TVA. Other sessions occurred in India, Ghana, and Bangladesh.

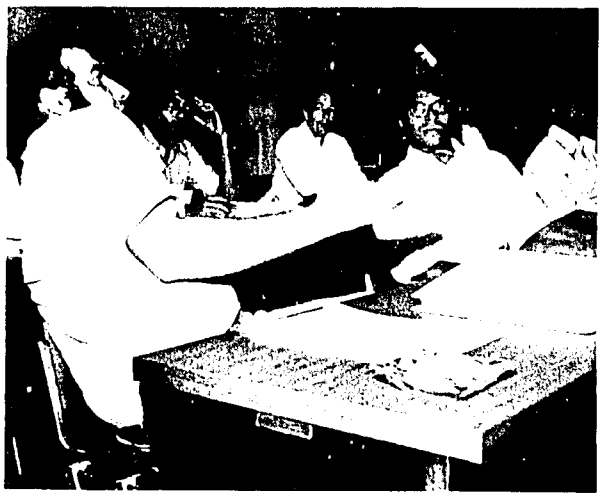
Formal Courses

IFDC Distribution Seminar–A 9-week seminar on fertilizer distribution began in August 1977 for 19 participants representing 10 different countries and organizations. The seminar goal was to increase the participants' knowledge of fertilizer marketing concepts with particular emphasis on physical distribution systems. A systems approach was used to analyze and develop methods of marketing and distribution to fit the range of agricultural conditions encountered in the participants' countries. Included in the seminar were presentations by IFDC staff members as well as guest lectures by staff from TVA, The World Bank, U.S. universities, fertilizer industries, and financial organizations. Field trips were arranged to U.S. port and distribution facilities which handle fertilizer from the producer to the farmer.

Factory Maintenance Course–Eight Bangladesh engineers from the Bangladesh Chemical Industries Corporation (BCIC) completed a 1-year "Fertilizer Factory Maintenance and Instrumentation Course" at IFDC in May 1977. The 1977 phase of the training program included a short course in organizational development and the formulation of a training program, complete with manuals and visuals, designed to be given in BCIC fertilizer factories. IFDC training and factory maintenance specialists will participate in the in-country phase of the maintenance training program to be held at three BCIC factory locations in early 1978.

Individualized Training

Rotary Foundation Fellowship–A Chemical Engineer, Mr. Prakash Acharya, from the Mangalore Fertilizer Company in India, began a 1-year program of training at IFDC in November 1977. Mr. Acharya had 3 years' experience as a shift leader for an ammonia plant in India. His program of work at IFDC seeks to broaden Mr. Acharya's experience through his participation in a wet-process phosphoric acid research group. Mr. Acharya is working with laboratory and intermediate pilot-scale production units.



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Technical Orientation for CRA—During July and August 1977, three Brazilian engineers, Mr. Jorge Soirefmann, Mr. J. Leonel Costa, and Mr. Eduardo Anselmo, from the Companhia Riograndense de Adubos (CRA) underwent a training program at IFDC and TVA to help prepare the engineers for the startup and operation of a new monoammonium phosphate (MAP) granulation plant being constructed in the port city of Rio Grande. As part of the program, the engineers visited phosphate complexes in North Carolina and Florida which produce phosphoric acid, MAP, DAP, and TSP. Visits were also made to NPK granular fertilizer plants in Alabama, Mississippi, and Missouri. The final phase of the assistance involved IFDC-sponsored engineers traveling to Brazil to assist CRA in training programs for the personnel scheduled to operate the new MAP facility.

Conferences and Seminars

West African Fertilizer and Soil Fertility Workshop—Ways to step up research on problems related to soil fertility in west Africa were the focus of discussion at an IFDC-sponsored 3-day workshop held in May 1977 at Accra, Ghana. The workshop, hosted by the Council for Scientific and Industrial Research (CSIR) of Ghana, brought together 29 soil fertilizer specialists representing various west African governments and international agencies. A key conclusion of the workshop was that problems of soil acidity are becoming more severe in areas where agriculture is being intensified. In particular, the effects on soil acidity of different fertilizers, liming, manure, and cropping systems were identified as key research areas. In view of favorable crop response to phosphate rocks of medium and high reactivity, workshop participants encouraged the continuation of phosphate rock evaluation studies in countries where such rocks can be delivered to the farm at a more economical price than soluble phosphate fertilizers. Additional recommendations were made to step up research activities on fertilizer requirements for different crops as affected by fertilizer-type and nutrient-release patterns. Most participants were also quick to identify the pressing need to more fully understand the constraints to increased fertilizer use in west Africa. Identified as high priority were public policy studies on the impact of alternative price, subsidy, and extension education programs.

1977 FAI-IFDC Fertilizer Seminar—Under the direction of Mr. Satya Nand, Executive Director of the Fertiliser Association of India, IFDC cosponsored the 1977 annual FAI Seminar held in December with the theme of "A Critical Look at the Fertilizer Industry Today and by 1990." The seminar goal was to identify directions which will boost the effectiveness of fertilizer used to produce India's food, future availability of raw materials for fertilizer production, and recent developments in the production, marketing, and distribution of fertilizers. IFDC coordinated the preparation of 17 papers for the seminar authored by IFDC staff as well as invited authors from TVA and other fertilizer-related institutions. Five IFDC staff members attended the seminar, including Dr. John Hannah, IFDC Board Chairman, who made a keynote address.

COMMUNICATIONS

Visitors Program

An international development organization like IFDC depends on frequent and continuing contact with other organizations to develop and carry out programs in fertilizer research and development, technical assistance, and training. In 1977, nearly 500 visitors, seminar participants, and trainees representing 58 countries traveled to IFDC for general orientation and in-depth discussions with the fertilizer staffs of both IFDC and TVA. Other than the United States, countries accounting for the largest number of visitors in order of magnitude include Brazil, India, Mexico, Japan, Bangladesh, Korea, Israel, Indonesia, the United Kingdom, Colombia, Ghana, Taiwan, Pakistan, Venezuela, and Hungary. For each visitor to IFDC a program of orientation meetings and discussions is arranged. Visitor interests cover a wide range of subjects such as: characterization and utilization of raw materials, fertilizer manufacturing processes, bulk-blending operations, factory maintenance and pollution control; soil-science research on nitrogen, phosphorus, and sulfur fertilization; and market intelligence and capital investment cost information. This continuing and growing interaction between IFDC staff and individuals from fertilizer-related organizations throughout the world is an important measure of IFDC's mission success to ensure that adequate fertilizers and fertilizer know-how exist to help accelerate agricultural development in developing countries.

Information Services

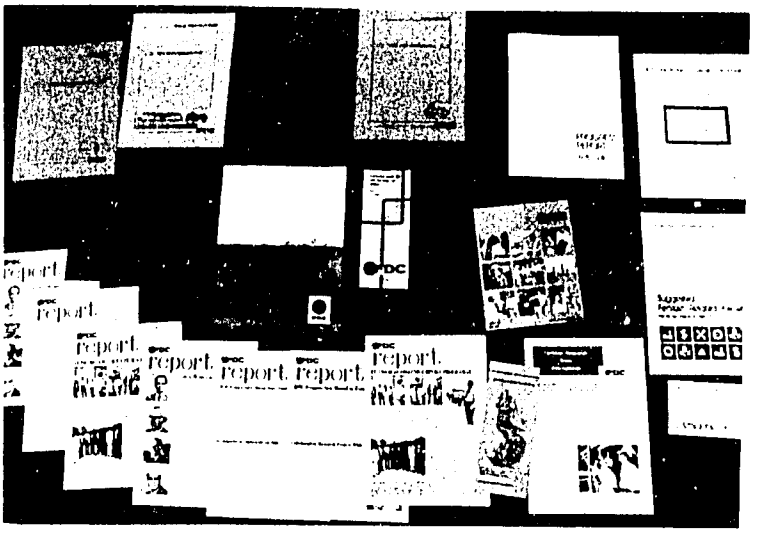
IFDC serves as both a clearinghouse and an originator of technical information related to fertilizer production, marketing, and use in the developing countries, with special emphasis on agriculture in the tropics and subtropics. A variety of publications and audio/ visual aids, and programs support IFDC communications.

IFDC Report—The intent of this quarterly newsletter is to provide capsulated reports on the work in progress at IFDC. Thirty-eight stories on program activities were included in the four editions published (in English and Spanish) during 1977. Approximately 1,300 names were on the mailing list during 1977 (1,000 English, 300 Spanish).

Administrative Publications—The *1975-76 IFDC Progress Report* was published in 1977. This report is written primarily for administrators and donors with highlights of significant program accomplishments. The general information booklet, *IFDC Story*, was revised and reissued in 1977. Also a number of IFDC-released articles appeared in newspapers and magazines in the United States and in developing countries. IFDC's personnel handbook was also revised and reissued in 1977.

Technical Bulletins and Scientific Papers—Formalized bulletins reports, and manuals are produced as either the output of a reimbursable project or to communicate to IFDC clientele about a subject of widespread interest. In 1977, seven bulletins were issued for general circulation. In addition, seven reports were prepared on a confidential basis for specific organizations on a reimbursable basis. Over 50 papers were prepared by IFDC staff members during 1977 for presentation at IFDC training seminars, for submission to professional journals, or in response to invitations to make presentations at conferences, seminars, and workshops hosted by other organizations.

Audio/Visual Services—Besides preparing graphic illustrations for IFDC papers and reports, over 20 slide presentations were made for IFDC staff and management covering individual research projects as well as overview presentations on IFDC goals and programs. Photodocumentation of IFDC building construction; equipment installation; and laboratory, training, greenhouse, and growth chamber activity occurred throughout the year. In addition, a number of poster displays were made for research and program presentations by staff.



Information services at IFDC include an active visitors program, communications via telex and letter, publication of technical information, and audio/visual presentations made by staff members. These services depend on the efforts of many support staff, some of whom are pictured here.

PUBLICATIONS

Reports

"West Africa Fertilizer Study (Volumes I-VII)," published by IFDC.
Volume I–Regional Overview
Volume II–Senegal
Volume IV–Upper Volta
Volume VI–Chad

"Economic and Technical Aspects of Fertilizer Production and Use in West Africa," T. Zalla, R. B. Diamond, and M. S. Mudahar, IFDC/MSU Working Paper No. 22, 1977.

"Suggested Fertilizer-Related Policies for Governments & International Agencies," published by IFDC.

"Progress Report, 1975-1976," published by IFDC.

Papers

"Fertilizer Policy Issues and Implications in Developing Countries," M. S. Mudahar and P. Pinstrup-Andersen, Presented at the Fertiliser Association of India/IFDC Seminar, New Delhi, India, 1977.

"Rice Fertilization for Optimum Yields," D. H. Parish and S. K. DeDatta, Presented at the Fertiliser Association of India/ IFDC Seminar, New Delhi, India, 1977.

"Utilization of Phosphate Rocks for Direct Application to Soils," E. C. Doll and L. L. Hammond, Presented at the FAO Workshop, Lima, Peru, 1977 (English or Spanish).

"Some Economic and Technical Factors Affecting Utilization of Phosphate Raw Materials," G. H. McClellan, Presented at the CIBA Foundation, London, 1977.

"Dissolution of Phosphate Rocks in Flooded Acid Soils," S. H. Chien, *Soil Science Society of America Journal*, Vol. 41, No. 6, Nov.-Dec., 1977.

"Thermodynamic Considerations of the Solubility of Phosphate Rock," S. H. Chien, *Soil Science*, Vol. 123, No. 2, 1977.

"Dissolution Rates of Phosphate Rocks," S. H. Chien, *Soil Science Society of America Journal*, Vol. 41, No. 3, May-June 1977.

"Phosphate Rock Characterization," G. H. McClellan and F. J. Klem, Presented at Fertiliser Association of India/IFDC Seminar, New Delhi, India, 1977.

"Trends in Ammonia Feedstocks," T. P. Hignett, Presented at the Fertiliser Association of India/IFDC Seminar, New Delhi, India, 1977.

"Prilling Compound Fertilizers," T. P. Hignett, Presented at the Fertiliser Association of India/IFDC Seminar, New Delhi, India, 1977.

"New Aspects of Fertilizer Technology in Better Exploitation of Plant Nutrients," R. C. Horn, Presented at FAO, Rome, Italy, 1977.

"Apatite Composition in Phosphate Rock as Related to Rock's Chemical Reactivity, Soil Solution P Concentration and Agronomic Effectiveness," G. H. McClellan, Presented at CLAMATROP, Malaysia, 1977.

"Evolving a National Fertilizer Data System in a Developing Country," Y. H. Chuang, Presented at the Fertiliser Association of India/IFDC Seminar, New Delhi, India, 1977.

"The Potential Impact of Changes in Income Distribution on Food Demand and Human Nutrition," P. Pinstrup-Andersen, Presented at Bellagio, Italy, 1977.

"Selected Economic Aspects of Agricultural Research," P. Pinstrup-Andersen, Presented at Ohio State University, 1977.

"World Fertilizer Market Review and Outlook," J. H. Allgood and P. J. Stangel, ADIFAL Seminar, San Salvador, El Salvador, 1977.

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March 24, 1978

To the Board of Directors of
International Fertilizer Development Center

In our opinion, the accompanying balance sheets and the related statements of revenue and expenses and changes in fund balances and of functional expenses present fairly the financial position of International Fertilizer Development Center (IFDC) at December 31, 1977 and 1976, and the results of its operations and changes in fund balances for the years then ended in conformity with generally accepted accounting principles consistently applied. Our examinations of these statements were made in accordance with generally accepted auditing standards and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

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INTERNATIONAL FERTILIZER DEVELOPMENT CENTER

BALANCE SHEETS

Assets

CURRENT FUND (unrestricted)

	December 31, 1977	December 31, 1976
Cash	$ 759,792	$ 400,403
Accounts receivable from donors (Note 2)	4,806,048	4,874,512
Other accounts receivable	111,591	153,826
Advances to employees	19,594	8,164
Prepaid expenses	95,165	5,397
	$5,792,190	$5,442,302

PROPERTY AND EQUIPMENT FUND (Notes 1 and 4)

	December 31, 1977	December 31, 1976
Buildings	$5,491,018	
Equipment	1,276,033	$ 192,656
Leasehold improvements		60,587
Construction-in-progress		3,825,036
Less - accumulated depreciation	(177,833)	(47,603)
	$6,589,218	$4,030,676

Liabilities and Fund Balances

CURRENT FUND (unrestricted)

	December 31, 1977	December 31, 1976
Accounts payable	$ 337,005	$ 178,374
Accrued annual and sick leave	184,480	92,552
Deferred revenue (Notes 1 and 3)	4,826,559	4,874,512
Total liabilities and deferred revenue	5,348,044	5,145,438
Fund balance	444,146	296,864
	$5,792,190	$5,442,302

PROPERTY AND EQUIPMENT FUND (Notes 1 and 4)

	December 31, 1977	December 31, 1976
Accounts payable	$ 108,839	$ 315,620
Contract retainage	36,699	177,220
Total liabilities	145,538	492,840
Fund balance	6,443,680	3,537,836
	$6,589,218	$4,030,676

INTERNATIONAL FERTILIZER DEVELOPMENT CENTER

STATEMENT OF REVENUE AND EXPENSES AND CHANGES IN FUND BALANCES

YEAR-ENDED DECEMBER 31, 1977 WITH COMPARATIVE TOTALS FOR 1976

	1977		Total All Funds	
	Current Fund	Property and Equipment Fund	1977	1976
Revenue:				
Grants received (Note 2)	$6,138,639		$6,138,639	$5,225,731
Recovered project costs	160,015		160,015	394,139
Other	13,207		13,207	3,430
Total revenue	6,311,861		6,311,861	5,623,300
Expenses:				
Research	1,465,401	$ 139,829	1,605,230	869,916
Outreach	800,311	29,106	829,417	610,364
General and administrative	795,629	28,459	824,088	558,814
Total expenses	3,061,341	197,394	3,258,735	2,039,094
Excess (deficiency) of revenue over expenses	3,250,520	(197,394)	$3,053,126	$3,584,206
Other changes in fund balances:				
Property and equipment acquisitions from unrestricted funds	(3,103,238)	3,103,238		
Fund balances, beginning of period	296,864	3,537,836		
Fund balances, end of period	$ 444,146	$6,443,680		

INTERNATIONAL FERTILIZER DEVELOPMENT CENTER

STATEMENT OF FUNCTIONAL EXPENSES

YEAR-ENDED DECEMBER 31, 1977 WITH COMPARATIVE TOTALS FOR 1976

	1977			Total Expenses	
	Research	Outreach	General and Administrative	1977	1976
Personnel compensation (Note 3)	$ 735,392	$424,269	$417,784	$1,577,445	$ 938,142
Personnel benefits (Note 3)	109,649	68,576	70,441	248,666	185,889
Travel and transportation	160,825	137,350	62,201	360,376	215,728
Occupancy (Note 4)	99,967	27,960	27,809	155,736	44,611
Telephone and telegraph	44,470	16,011	25,049	85,530	48,843
Rental of equipment	28,343	42,327	56,442	127,112	61,157
Contractual research and development	68,559	10,000		78,559	228,603
Other contractual services	105,478	45,584	36,110	187,172	170,133
Institute of International Education fee (Note 3)			43,700	43,700	25,000
Materials and supplies	112,718	28,234	33,797	174,749	78,286
Postage			11,406	11,406	3,781
Insurance			10,890	10,890	2,520
Miscellaneous	19,388	3,258		22,646	986
Total expenses before depreciation and amortization	1,484,789	803,569	795,629	3,083,987	2,003,679
Depreciation of furniture and equipment and amortization of leasehold improvements	120,441	25,848	28,459	174,748	35,415
Total expenses	$1,605,230	$829,417	$824,088	$3,258,735	$2,039,094

INTERNATIONAL FERTILIZER DEVELOPMENT CENTER

NOTES TO THE FINANCIAL STATEMENTS

DECEMBER 31, 1977 and 1976

NOTE 1 - ORGANIZATION AND ACCOUNTING POLICIES:

The International Fertilizer Development Center (IFDC) is a non-profit organization incorporated October 7, 1974 under the state laws of Alabama. On March 14, 1977, IFDC was designated as a public international organization by executive order of the President of the United States. The purpose of the organization is to improve fertilizers and fertilizer know-how in developing countries through research and development, technical assistance and training and communications.

In the event of dissolution, the articles of incorporation provide that the residual assets of the organization will be turned over to one or more tax exempt organizations or to the federal, state or local government for exclusive public purpose.

The following is a summary of significant accounting policies:

A. Property and equipment is stated at cost. Depreciation and amortization is computed on the straight-line method over estimated useful lives ranging from three to thirty years.

B. Revenue and expenses are accounted for on an accrual basis. In particular, grants of the United States Agency for International Development (AID) are recorded as receivable for the full amount at the date of the grant. Amounts not clearly designated for a specified program period are deferred in the balance sheet and reflected in revenue when received. Contributions for reimbursable costs are recognized as project costs are incurred.

Revenue is restricted only to the extent it is to be used in accordance with the purpose of the organization unless otherwise indicated.

NOTE 2 - GRANTS:-

Grants received are summarized as follows:

	Year ended December 31, 1977	Year ended December 31, 1976
United States Agency for International Development (AID)	$ 5,700,000	$ 6,900,000
International Development Research Center (IDRC)	310,175	
Rockefeller Foundation	20,511	28,911
Israel Chemicals Limited	50,000	
Fertilizer and Pesticide Authority	10,000	
	6,090,686	6,928,911
Amounts deferred during prior year	4,874,512	3,171,332
	10,965,198	10,100,243
Less - Amounts deferred to future periods	(4,826,559)	(4,874,512)
Revenue recognized in current period	$ 6,138,639	$ 5,225,731

The current grant from AID was amended to provide additional funds of $5,700,000 and $6,900,000 during the years ended December 31, 1977 and 1976, respectively, and to extend the grant period from June 29, 1977 to December 31, 1978. The amounts of $4,645,249 and $4,860,112 had not been received at December 31, 1977 and 1976, respectively, and were not clearly designated for a specified program period and, accordingly, were deferred. The amendment to the grant provides funds for the construction of new office and research facilities and equipment. The use of funds by area is unrestricted except that equipment purchases may not exceed $3,022,000. Funds not legally committed at the grant expiration date will revert to AID.

The amount of $20,511 from the Rockefeller Foundation grant and the amount of $160,799 from the International Development Research Center grant were deferred at December 31, 1977.

NOTE 3 - INSTITUTE OF INTERNATIONAL EDUCATION:

IFDC has a contract with the Institute of International Education (IIE) relating to the employment of personnel of IFDC. All payroll administrative functions are performed by IIE; IFDC makes advances quarterly to fund salaries, employment taxes and fringe benefits.

NOTE 4 - FACILITIES:

Prior to the completion of the building facilities funded by a grant from AID, the building used for research and development and outreach programs and administrative office space were leased. The building used for the research and development and outreach programs was leased for a three year period at an annual rate of $2,900. Administrative office space and additional space for outreach programs were leased on a month-to-month basis; rental expense was $13,100 and $17,700 for the years ended December 31, 1977 and 1976, respectively.

Staff

Office of the Managing Director

Donald L. McCune, Managing Director
Paul J. Stangel, Deputy Managing Director
Marjorie R. Engel, Administrative Director
Kaye F. Barker, Student Worker (Accounting)
Iris A. Cifuentes, Bilingual Secretary
Christopher R. Dowswell, Communications Specialist
Roger C. Franklin, Librarian
Debra R. Garrett, Executive Secretary
Travis P. Hignett, Special Consultant to the Managing Director
Richard D. Kapocsi, Comptroller*
W. Dianne Kasmeier, Clerk (Purchasing)
James M. Kelly, Purchasing Agent
Janice S. Martindale, Secretary
Jeffrey F. McGee, Student Worker (Mail Room)
Jean G. Meyer, Mail Clerk
Sidney Painter, Personnel Officer
Brenda G. Peden, Accounting Clerk
Manuel Sanchez-Nelson, Special Assistant to the Managing Director
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Gwendolyn A. Watts, File Clerk
Linda S. White, File Clerk
Cynthia B. Woodward, Public Relations Officer

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G. William Easterwood, Chemical Laboratory Analyst
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Christina H. Gladwin, Postdoctorate Fellow
Lawrence L. Hammond, Soil Scientist
Rebecca Hufstedler, Research Assistant
James T. Kennedy, Chemical Laboratory Analyst
L. Alfredo Leon, Soil Scientist
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John M. Stumpe, Analytical Chemist
Hernan R. Tejeda, Agronomist and Statistician
Paul L.G. Vlek, Soil Scientist

*Left during 1977.

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Jerry R. Clemmons, Chemist
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Jorge R. Polo, Chemical Engineer
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Johnnie W. Riley, Maintenance Technician
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Andre Varsanyi, Visiting Scientist
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Richard L. Booth, Systems Analyst
David Braude, Visiting Economist
Jerry W. Carter, Part-Time Data Abstractor
Yao H. Chuang, Coordinator, World Fertilizer Information Services
John T. Colagross, Media Technician
Ray B. Diamond, Regional Coordinator–Africa
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Flora M. Hamner, Technical Illustrator
John M. Hill, Marketing Development Specialist
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Larry W. Taylor, Student Worker
Lueder von Bremen, Visiting Economist

As of December 31, 1977

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